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HEARN TGS VACUUM DEGASSIFIER UNIT: ASKAREL AEROSOL/VAPOUR REMOVAL SYSTEM AND EMISSIONS MONITORING

Report No. 91-211-K

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ABSTRACT

Hearn TGS Operations have acquired a vacuum degassifier unit (VDU) to remove volatile contaminants, such as water, from askarel oil that is used in the station transformers. Because of the high polychlorinated biphenyl (PCB) content of the transformer oil (up to 70%), the Ministry of the Environment (MOE) requested that protective measures be put in place to ensure that PCB aerosol and vapour releases to the environment are kept as low as possible. To accommodate the MOE request, an aerosol and vapour removal system was designed and installed on the VDU. A vent gas emissions sampling program was also recommended to further convince the MOE of the integrity of the air exhausted from the VDU. The aerosol and vapour removal system is described in detail in this report. The PCB concentrations measured at the VDU cleanup system outlet were less than the MOE point of impingement (POI) value of 450 ng/m^3. A POI calculation as defined in Regulation 308 was applied to the VDU case at a 1 metre distance from the cleanup system outlet. The PCB concentrations measured at the POI were 100 times less than those measured at the cleanup system outlet. During the operation of the VDU very little air is actually vented to the atmosphere. The majority of the vent gas was emitted during the initial pump-down to obtain the 10^{-3} Torr vacuum during the two commissioning tests.

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1.0 INTRODUCTION

A vacuum degassifier unit (VDU) was purchased from Enervac Corporation by Hearn Thermal Generating Station to remove volatile contaminants from the askarel oil used in station transformers. Before degassification of the askarel oil could proceed, a special approval to pump the PCB oil through the VDU and back into the transformer had to be obtained from the Ministry of the Environment (MOE) because of the high polychlorinated biphenyl (PCB) content of the transformer oil (up to 70%). The MOE asked that protective measures be put in place to ensure that PCB aerosol and vapour releases to the atmosphere were kept as low as possible.

The Environmental Physics & Chemistry Section received a request from Hearn TGS to design an aerosol and vapour removal system (AVRS) for the VDU, to ensure that the Ministry of the Environment and Ministry of Labour PCB emission standards and worker exposure limits were not exceeded during operation. To further convince the MOE of the integrity of the air being exhausted by the AVRS, an emissions sampling program was recommended to Hearn TGS operating staff.

The VDU AVRS and the emissions sampling program are described in Section 2.0. The results of the stack emissions measurements obtained during the two VDU commissioning runs and a brief discussion are presented in Section 3.0. Summary and conclusions are presented in Section 4.0.

2.0 EXPERIMENTAL

2.1 Exhaust Gas Cleanup System

The VDU purchased by Hearn TGS can process askarel transformer oil at rates up to 100 gal/h. The volatile contaminants in the askarel oil are removed under a vacuum of about 10^{-3} Torr. A Kinney Model KD-50 vacuum pump, rated at 52 cfm (free air), provided the vacuum for the VDU system. The exhaust port of the vacuum pump is the only pathway for askarel particles and vapour to escape from the VDU during operation. Figure 1 shows a schematic of the exhaust gas cleanup system that was attached to the vacuum pump exhaust.

Aerosols produced during VDU operation were removed with a Balston aerosol filtering system. A Balston Model ACV-0735-371H vacuum exhaust filter housing, containing seven Model 200-35-371H microfibre filter cartridges, was attached to the outlet of the Kinney vacuum pump. The housing is constructed of 304 stainless steel with all sealing 'O'-rings made of Viton. The filter cartridge efficiency, as claimed by the manufacturer, was 99.9% for an aerosol mean diameter of 0.1 µm at a free air flowrate of 52 cfm. The microfibre cartridges were evaluated in an earlier study/1/ where the manufacturer quoted filter efficiencies were confirmed.

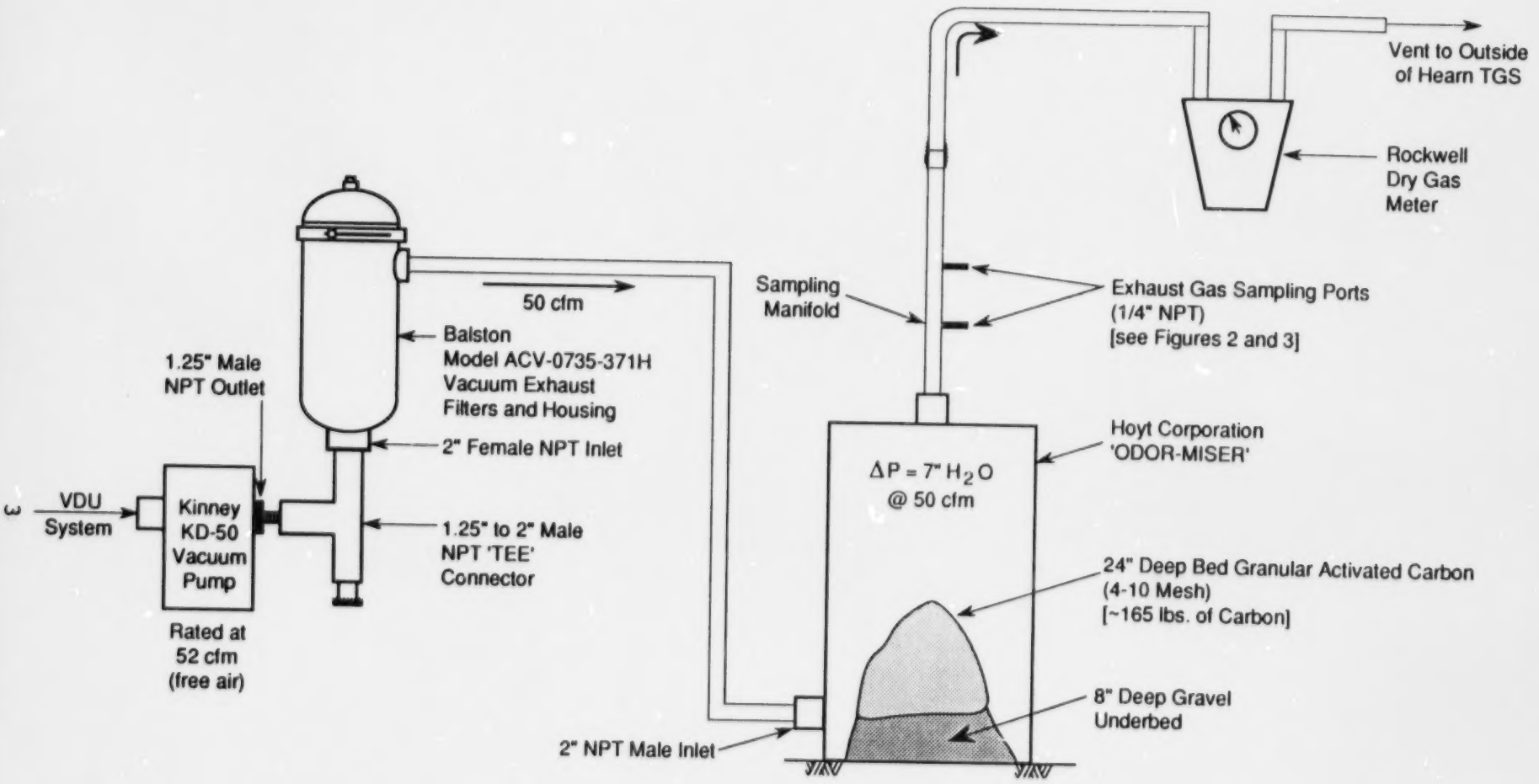

FIGURE 1

SCHEMATIC DIAGRAM OF EXHAUST GAS CLEANUP SYSTEM USED WITH THE VACUUM DEGASSIFIER UNIT

To remove any vapour phase askarels that might be emitted during the degassification process, a Hoyt Corporation "Odor-Miser" was attached to the outlet of the Balston aerosol filtering system. The "Odor-Miser" is a large steel drum (about 23" in diameter by 36" in height) containing approximately 165 lbs of 4/10 mesh activated charcoal (Calgonite). The pressure drop across the drum is about 7" H_2O at 52 cfm. The charcoal bed depth is about 24". The estimated capacity of the charcoal at 100 cfm is about 30% by weight of the charcoal present (about 49 lb of contaminant).

2.2 Exhaust Gas Sampling

To convince the MOE that the gas emissions from the VDU exhaust cleanup system are well below MOE air emission standards, air samples were collected on Florisil filled tubes from the sampling manifold attached to the "Odor-Miser" outlet. The askarel content of the Florisil tubes was determined by the Analytical Services Section of Research Division. The sampling procedures used were similar to those employed during the MPU-2 emissions sampling programs/2,3/.

A 2 foot length of 2" OD cast steel pipe was attached to the outlet of the "Odor-Miser" to serve as the gas sampling manifold. Into this manifold were drilled and tapped two holes (0.25 NPT thread) to serve as the sampling ports. Their location in the VDU cleanup system is shown in Figure 1.

Figures 2 and 3 depict in more detail the PCB sampling train and sampling system components used. Sampling tubes containing Florisil sorbent (SKC, 6mm OD x 70mm), obtained from Integra Environmental Inc., were used to concentrate the air samples taken from the manifold. The two Florisil tubes, arranged in series, were sealed into drilled out 1/4" stainless steel and Teflon Swagelok fittings using soft graphite 1/4" M-2A ferrules (Supelco Canada Ltd) as shown in Figure 3. The Swagelok fittings were drilled out to allow the Florisil sampling tubes to be inserted through the fittings. Two Tylan mass flow controllers (Model FC-280) in conjunction with a DIA-VAC™ (Air Dimensions, Inc.) dual stage pump, were used to draw the required air flows from each sampling port through each sampling train. Polyethylene sampling lines (1/4" OD) were used to attach the outlet of the air sampling trains to the mass flow controllers and pump head.

2.3 Calibration

Each of the Tylan mass flow controllers was calibrated with a sampling train containing two Florisil sampling tubes in series with the sampling pump, to simulate the pressure drop that would be present during field sampling. The actual flows were measured with a microprocessor-controlled bubble metre ("Buck" calibrator).

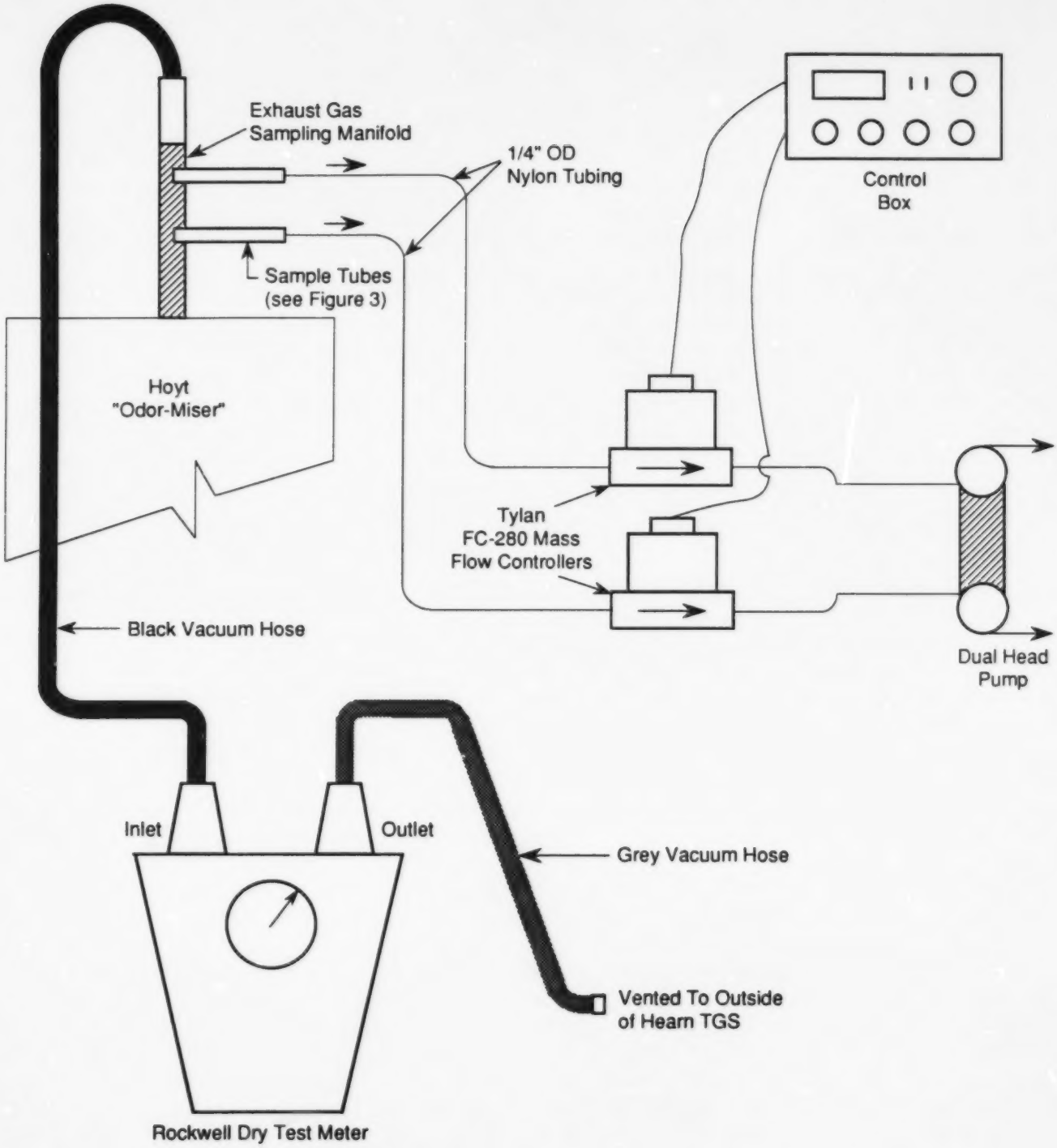

FIGURE 2

**SCHEMATIC OF STACK TESTING SYSTEM
FOR VDU AT HEARN TGS**

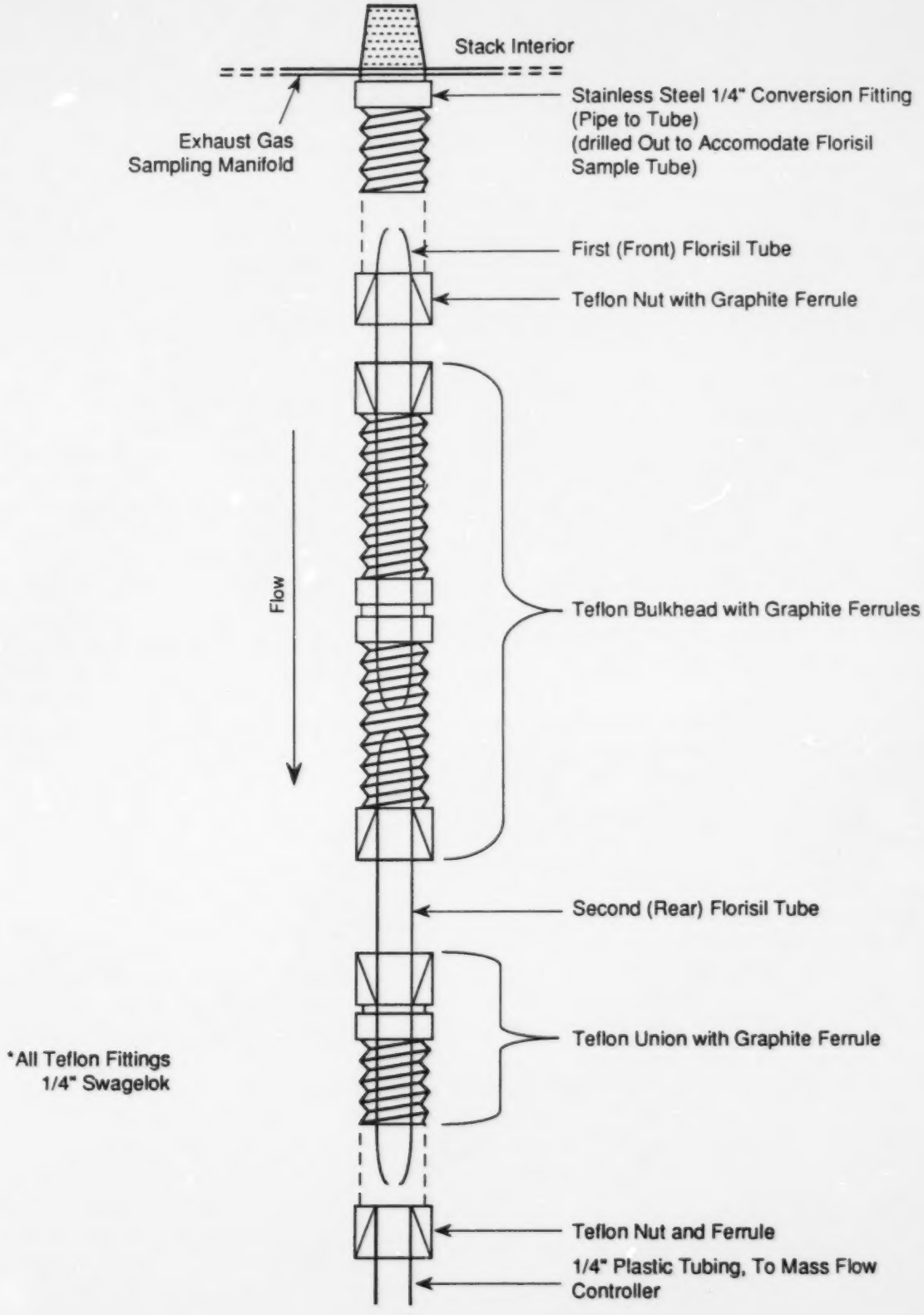

FIGURE 3

SCHEMATIC DIAGRAM OF FLORISIL SAMPLE TUBE ARRANGEMENT USED TO MONITOR PCBs IN VDU EXHAUST

186254-L18-RD

2.4 Procedure

Twenty-four and 48-hour sampling intervals were used for samples collected during the work week, and a 72-hour sampling interval was used for samples collected over a weekend. The flow rate through the sampling trains was maintained at 33 mL/min.

3.0 RESULTS AND DISCUSSION

3.1 Calibration of Flow Measuring Devices

3.1.1 Sampling System Flow Controllers

The Tylan Model FC-280 mass flow controller calibrations done both before and after the testing program are available upon request from the Environmental Physics and Chemistry Section (EP&C) of Ontario Hydro Research. These results confirmed that the two Tylan FC-280 mass flow controllers remained unchanged during the two test periods.

3.1.2 Dry Gas Meter

The calibration data provided by MKS for the dry gas meter, along with the tables of correction factors and graphs of these factors versus flow rate, obtained with a calibrated mass flow controller, are also available upon request from EP&C.

All volumes recorded during the tests were corrected using the appropriate factors and are considered to be accurate within the normal range of a dry gas meter.

3.1.3 Sample Collection

The vent gas sampling program generated 9 sets of four samples and two sets of six samples. All 11 sets were analyzed for PCB. Each sample set consisted of a first and a second adsorption tube with four sample sets having a third adsorption tube; this represented a total of 48 Florisil tubes and 4 blanks. Each tube in turn consisted of front and back sections that were analyzed separately, giving a potential for 104 PCB analyses.

The analytical protocol required that the second adsorption tube from a sample be analyzed only if a significant quantity of the analyte was found in the back section of the first adsorption tube. Consequently, the actual number of analyses was somewhat less than the above numbers.

3.1.4 Analysis of Samples

The following emission results have been derived from the analytical reports provided by the Analytical Services Section of Ontario Hydro Research/4,5/.

Two VDU commissioning tests were conducted using the Hearn TGS Unit 5 station service transformer which contains about 900 gallons of askarel. The first commissioning test was run for approximately 75 hours. This allowed the entire askarel oil content of the transformer to be passed through the VDU at least 6 times. The second commissioning test was run for a longer period of time, about 334 hours. The entire askarel oil loading of the transformer was passed through the VDU about 25 times.

The exhaust gas sampling results for both commissioning tests are presented in Table I.

3.1.5 Emission Concentrations

The Ministry of the Environment Point of Impingement (POI) and Ambient Air Quality criteria for PCB are 450 ng/m^3 and 150 ng/m^3, respectively/6/. The Ministry of Labour Time-Weighted Average Exposure Criteria (TWAEC) for PCB is 50 µg/m^3/7/.

3.1.6 Point of Impingement Concentration Calculations

The permissible emission of a pollutant from a mobile processing unit, such as the VDU, should be determined based on one-half hour concentration of pollutants in the air at the POI. For such a calculation the following model, included in the Ministry of the Environment Regulation 308 /6/, could be extended to the VDU case:

$$K = 0.6 \times 10^6 \times Q \times L^{-2}$$

where:

K is the half-hour average concentration at the point of impingement in micrograms per cubic metre,

Q is the rate of emission in grams per second of the contaminant,

L is,

i) the product of 1.57 and the straight line distance in metres between the point of emission and the point of impingement if the point of impingement is lower in height above grade than the point of emission, or

ii) the straight line distance in metres between the point of emission and the point of impingement where the point of impingement is at the same height or higher above grade than the point of emission.

TABLE I

VENT GAS AND POINT OF IMPINGEMENT CONCENTRATIONS AND EMISSION RATES OF POLYCHLORINATED BIPHENYLS FOR THE HEARN TGS VACUUM DEGASSIFIER UNIT EMISSION TESTS

Sampling Date (1991)	Total Sampling Time (hours)	Total Flow Florisil Sample Tube (litres)	PCB Concentrations "Odor-Miser" Outlet (ng/m^3)	Total Flow in Stack (litres)	PCB Emission Rate Q (ng/s)	Point of Impingement Concentrations (ng/m^3) A	B′
First Commissioning Test - March 4 to 7, 1991							
Mar 4	3.9	7.81	<1280	187	<1.37	<0.82	<0.33
Mar 4-5	22.6	44.78	< 223	14.6	<0.04	<0.024	<0.010
Mar 5-6	24.7	48.94	< 204	0.0	0.0	0.0	0.0
Mar 6-7	23.9	47.39	< 211	0.0	0.0	0.0	0.0
Second Commissioning Test - March 13 to 27, 1991							
Mar 13-14	23.2	45.89	< 218	258.7	<2.61	<1.57	<0.64
Mar 14-15	23.3	46.50	< 215	0.0	0.0	0.0	0.0
Mar 15-18	72.3	143.20	83.8	0.0	0.0	0.0	0.0
Mar 18-20	47.5	94.07	< 106	0.0	0.0	0.0	0.0
Mar 20-22	48.0	95.04	< 105	1050.0	<0.64	<0.38	<0.16
Mar 22-25	72.0	142.53	< 70.2	445.3	<0.12	<0.072	<0.029
Mar 25-27	48.1	95.14	< 105	0.0	0.0	0.0	0.0

For Point of Impingement Calculation A, L = 1 m and B′, L = 1.57 x 1 m

* Ministry of the Environment POI criterion: 450 ng/m^3 (Ref. 6)

* Ministry of Labour criterion: 50 $\mu g/m^3$ (Ref. 7)

It is understood that for the VDU a point of impingement can be at the same height or lower in height above grade than the point of emission. The calculated POI concentrations are listed in Table I for two impingement points. The A value was calculated using L and the B' value was calculated with a 1.57 x L factor. The PCB POI concentrations, calculated for a worst case scenario, ie, direct venting of the "Odor-Miser" outlet to the local working environment (no extension hose to vent out of building), are listed in Table I. For A and B' impingement point calculations, L = 1 m was used as the estimated closest approach by Hearn TGS personnel to the vent opening during VDU operation.

As shown in Table I, the vent gas cleanup system controls PCB emissions effectively. The MOE POI concentration limit for PCB is 450 ng/m^3, whereas the PCB vent gas concentrations in the sampling manifold were less than this value. The PCB concentrations calculated for the A and B' impingement points were at least 100 times less than the MOE POI concentration guideline.

4.0 SUMMARY and CONCLUSIONS

The vent gas emissions from the VDU AVCS were sampled during the processing of askarel oil from the Hearn TGS Unit 5 station transformer. The PCB concentrations were at or below the detection limits for all samples.

The VDU AVCS controls PCB release to the local environment. The AVRS outlet concentrations were below the MOE POI and AAQS criteria and the Ministry of Labour TWAEC value.

It is recommended that the PCB sampling trains be run at slightly higher flow rates (50 to 100 mL/min) to further increase the sensitivity of the emissions sampling. The MOE is recommending the use of XAD-2 sorbent instead of Florisil for ambient air sampling of PCB. It is recommended that a series of parallel samples be taken using Florisil and XAD-2 sorbent trains to investigate the sampling sensitivity.

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